

What we claim:

1. method for preventing an aircraft from penetrating into a dangerous trailing vortex area of a vortex generator where:

information on the aircraft configuration, position, and orientation with respect to the inertial frame is received at the current time;

information on the vortex generator position, geometrical and weight characteristics, as well as on the generator motion parameters with respect to the inertial frame is received at the current time;

information on the vortex generator position and motion parameters in the inertial frame is saved;

information on ambient parameters in the region of the aircraft and vortex generator collocation is received at the current time;

the generator vortex trajectory in the form of the set of the generator vorticity region center trajectories in the inertial frame, as well as the generator vortex intensity are determined at the current time;

information on the generator vortex trajectory points in the form of the set of the generator vorticity region center trajectories in the inertial frame, as well as on the generator vortex intensity is saved;

the delay time within which the aircraft has a possibility of a flight evasive maneuver providing evasion of the aircraft from the generator vortex danger area after the signal warning against the possibility of wake encounter has been received is selected;

the delay distance, which equals to the distance covered by the aircraft during the delay time is calculated, the control plane located in front of the aircraft perpendicular to its flight direction at the delay distance is modeled, and the forecasted time necessary for the aircraft to gain the control plane in the inertial frame is determined;

the geometrical characteristics of the generator wake vortex danger areas in the form of the set of the danger areas of the generator vorticity regions are determined at the forecasted time;

the generator wake vortex path in the form of the set of the generator vorticity region centers with respect to the inertial frame and the intensity of the wake vortices are determined at the forecasted time;

the coordinates of the intersection point of the generator wake vortex trajectory and the above control plane are determined at the forecasted time of the aircraft flight through it;

the wake vortex danger area in the form of the set of the generator vorticity danger areas, where the entering aircraft can have the flight parameters exceeding the admissible limits is formed around the above intersection point; the area of the aircraft forecasted positions at the forecasted time of the aircraft intersection with the above control plane is formed with due regard to the flight regulations is formed in the above control plane; the alert area is formed around the region of the aircraft forecasted positions; the information on the entrance of the wake danger areas into the alert area is provided to the user;

the coordinates of the points of the area of the aircraft forecasted positions, of the alert area and of the wake vortex danger areas in the aircraft frame are determined;

the distance from the alert area to the danger area of wake vortices in the control plane is calculated;

the distance from the area of the aircraft forecasted positions to the danger area of wake vortices is calculated;

indication for the user of the nulling of the distance from the warning area to the danger area of the generator wake vortices is performed;

emergency indication for the user of the nulling of the distance from the warning area to the danger area of the generator wake vortices is performed.

2. The method as claimed in claim 1 wherein:

the information on the generator type, flight velocity, angular rate, and coordinates of the generator path points is preferably used as the information on the generator position, geometry, weight, and motion parameters;

information on the generator path point coordinates, flight velocity, and angular rates of the vortex generator in the inertial frame is saved;

the information on the local wind velocity and direction, altitude wind profile, turbulence intensity, and the underlying terrain type is preferably used as the information on the ambient parameters;

the trajectory and intensity of the generator wake vortices in the form of the set of the generator vorticity area centers at the current time is calculated on the basis of the saved information on the type of the vortex generator, its path point coordinates, flight velocity and angular rates;

the control plane is simulated on the basis of information on the aircraft location, attitude, flight velocity and the chosen delay time at the current time moment in the inertial frame;

the danger area geometry of the generator wake vortices in the form of the set of the generator vorticity danger areas is evaluated on the basis of the saved information on the path point coordinates of the generator wake vortices as the set of the trajectories of the generator vorticity area centers in the inertial frame and the wake intensity, as well as on the basis of information on the aircraft configuration, position, flight velocity, and angular rates in the inertial frame;

the trajectory and intensity of the generator wake vortices at the predicted time are evaluated on the basis of information on the trajectory and intensity of the generator wake vortices in the form of the set of the trajectories of the generator vorticity area centers in the inertial frame;

the coordinates of the intersecting points of the generator wake vortex trajectory with the control plane at the predicted time are evaluated on the basis of information on the control plane coordinates in the inertial frame and on the generator wake vortex trajectory in the inertial frame at the predicted time;

the generator wake vortex danger area in the control plane, the aircraft forecasted position and alert areas are formed on the basis of information on the coordinates of the intersection points of the generator wake vortex trajectory with the control plane at the predicted time, information on the danger area geometry of the generator wake vortices in the form of the set of the generator vorticity danger areas, information on the location, attitude, flight velocity and angular rates of the aircraft with due regard for the flight regulations currently in force;

the coordinates of the area of the aircraft forecasted positions, coordinates of the alert area and coordinates of the wake vortex danger area in the aircraft frame are calculated on the basis of information on the coordinates of the alert area, of the area of the aircraft forecasted positions with due regard for the flight regulations currently in force and of the wake vortex danger area at the predicted time, as well as on the basis of information on the aircraft coordinates and its attitude, preferably, on the aircraft angles of pitch, yaw, and roll in the inertial frame at the current time.

3. The method as claimed in any claims 1-2 wherein the method operations are carried out simultaneously with respect to each of the wake vortex generators located in the vicinity of the aircraft.

4. The method as claimed in any of claims 1–3 wherein the delay time is currently corrected.
5. The method as claimed in any of claims 1-4 wherein the coordinates of the area of the aircraft forecasted positions are currently corrected.
6. The method as claimed in any of claims 1–5 wherein the coordinates of the alert area are currently corrected.
7. The method as claimed in any of claims 4–6 wherein the current correction is carried out by means of manual control.
8. The method as claimed in any of claims 4–6 wherein the current correction is carried out by means of semiautomatic or automatic control.
9. The method as claimed in any of claims 1- 8 wherein the user is provided with information on the coordinates of the control plane, alert area, area of the aircraft forecasted positions and the generator wake vortex danger areas located in the vicinity of the aircraft.
10. The method as claimed in any of claims 1–9 wherein the user is provided with visualization of information on the position of the area of the aircraft forecasted positions, alert area and danger areas of the generator wake vortices in the control plane.
11. The method as claimed in any of claims 1–10 wherein the indication of nulling of the distance form the alert area to the danger zone of the generator wake vortices in the control plane and/or the emergency indication of nulling of the distance from the area of the aircraft forecasted positions to the danger area of the generator wake vortices is performed by means of indication chosen from the group including visual, audio and tactile indication.
12. The method as claimed in any of claims 1–11 wherein the information on the selected delay time, on the coordinates of the control plane, of the area of the aircraft forecasted positions and of the danger areas of the generator wake vortices is stored during the emergency indication of nulling of the distance from the area of the aircraft forecasted positions to the danger area of the generator wake vortices.

13. A system for preventing an aircraft from penetration into a dangerous trailing vortex area of a vortex generator, the system comprising:

the aircraft parameters tracker (1) capable of receiving information on the aircraft configuration, location and attitude with respect to the inertial frame at the current time;

the vortex generator tracker (2) capable of receiving information on the position, geometry and weight characteristics, as well on the motion parameters of the wake vortex generator with respect to the inertial frame at the current time;

the memory device (3) capable of saving information on the vortex generator position and motion parameters in the inertial frame;

the ambient parameters detector (4) capable of receiving information on the ambient parameters in the area of the aircraft and generator collocation at the current time;

the wake vortex tracker (5) capable of determining the generator wake path in the form of the set of the generator vorticity area centers in the inertial frame and the wake vortex intensity;

the memory device (6) capable of saving information on the generator wake path coordinates in the form of the set of the generator vorticity area centers in the inertial frame and on the wake vortex intensity;

the device (7) for selection of the delay time capable of calculating the time period within which the aircraft has at least a possibility of a flight evasive maneuver providing evasion of the aircraft from the generator wake danger area after the signal warning against the possibility of wake encounter has been received;

the device (8) for simulation of the control plane capable of calculating the delay distance, which equals to the distance covered by the aircraft during the delay time, modeling the control plane situated in front of the aircraft perpendicular to its flight direction at the delay distance, and determining the forecasted time necessary for the aircraft to gain the control plane in the inertial frame;

the device (10) for determination of the danger area parameters capable of determining the geometrical characteristics of the generator wake vortex danger areas in the form of the set of the danger areas of the generator vorticity regions at the forecasted time;

the forecasting device (9) capable of determining the generator wake path in the form of the set of the generator vorticity region centers with respect to the inertial frame and of the intensity of the generator wake vortices at the forecasted time;

the device (11) for calculation of the intersection points capable of determining the coordinates of the intersection points of the generator wake vortex trajectory and the control plane at the forecasted time of the aircraft flight through it;

the areas and regions forming device (12) capable of forming around the intersection point of the wake vortex path and the control plane of the wake vortex danger area in the form of the set of the generator vorticity danger areas, where the entering aircraft may have the flight parameters exceeding the admissible limits; forming in the control plane of the area of the aircraft forecasted positions at the forecasted time of the aircraft intersection with the control plane with due regard for the flight regulations; forming around the region of the aircraft forecasted positions of the alert area; the information on the entrance of the wake danger areas into the alert area should be provided to the user;

the transformation unit (13) capable of calculating the coordinates of the area of the aircraft forecasted positions, of the alert area and of the wake vortex danger area in the aircraft frame;

the first intersection conditional test unit (14) capable of calculating the distance from the alert area to the wake vortex danger area and marking its nulling;

the second intersection conditional test unit (15) capable of calculating the distance from the area of the aircraft forecasted positions to the wake vortex danger area and marking its nulling;

the indication unit (16) capable of indicating the nulling of the distance from the alert area to the generator wake vortex danger area;

the emergency indication unit (17) capable of indicating the nulling of the distance from the area of the aircraft forecasted positions to the danger area of the generator wake vortices.

14. The system as claimed in claim 13 wherein:

the aircraft parameters tracker (1) is capable of receiving information at least on the aircraft configuration, coordinates, flight velocity, and angles of pitch, yaw and roll;

the vortex generator tracker (2) is capable of receiving information at least on the generator type, flight velocity, angular rates, and coordinates of the trajectory points;

the ambient parameters detector (4) is capable of receiving information at least on the magnitude and direction of the local wind velocity, altitude wind profile, turbulence level, and type of underlying terrain;

the wake vortex tracker (5) is capable of determining the generator wake path in the form of the set of the generator vorticity area centers and the wake vortex intensity on the basis of the saved information on the generator type, trajectory points coordinates, flight velocity, and angular rates;

the device (8) for simulation of the control plane is capable of modeling the control plane on the basis of information on the aircraft position, attitude, and flight velocity, as well as on the delay time;

the device (10) for determination of the danger area parameters is capable of determining the geometrical characteristics of the generator wake vortex danger areas on the basis of the saved information on the vortex generator trajectory points coordinates and the wake vortex intensity, as well as on the aircraft position, flight velocity, and angular rates in the inertial frame;

the forecasting device (9) is capable of determining the vortex generator wake path and the wake vortex intensity on the basis of information on the wake vortex path in the form of the set of the generator vorticity region centers and on the generator wake vortex intensity in the inertial frame;

the device (11) for calculation of the intersection points is capable of determining the coordinates of the intersection points of the generator wake vortex trajectory and the control plane on the basis of information on the control plane coordinates and the wake vortex path in the inertial frame at the forecasted time;

the areas and regions forming device (12) is capable of forming the wake vortex danger area, the area of the aircraft forecasted positions, and the alert area on the basis of information on the coordinates of the intersection points of the generator wake vortex trajectory and the control plane at the forecasted time, information on the danger area geometrical characteristics in the form of the set of the generator vorticity danger areas, information on the aircraft position, attitude, flight velocity, and angular rates in the inertial frame with due regard for flight rules and standards;

the transformation unit (13) is capable of calculating the coordinates of the area of the aircraft forecasted positions, of the alert area and of the wake vortex danger area in the aircraft frame on the basis of information on the coordinates of the alert area, the area of the aircraft forecasted positions and the wake vortex danger area at the forecasted time in the inertial frame and on the basis of information on the aircraft coordinates and attitude, preferably on the aircraft angles of pitch, yaw and roll, in the inertial frame at the current time.

15. The system as claimed in any of claims 13–14 wherein it comprises the vortex generator tracker (2), memory devices (3, 6), wake vortex tracker (5), device (10) for determination of the danger area parameters, forecasting device (9), device (11) for calculation of the intersection points, areas and regions forming device (12), first and second intersection conditional test units (14, 15), indication device and emergency indication device capable of providing simultaneous performance of their functions with respect to each of vortex generators located in the vicinity of the aircraft.

16. The system as claimed in any of claims 13–15 wherein the device (7) for selection of the delay time is capable of adjusting currently the delay time.

17. The system as claimed in any of claims 13–16 wherein the areas and regions forming device (12) is capable of adjusting currently the coordinates of the area of the aircraft forecasted positions.

18. The system as claimed in any of claims 13–17 wherein the areas and regions forming device (12) is capable of adjusting currently the coordinates of the warning area.

19. The system as claimed in any of claims 16–18 wherein the correction is accomplished by means of manual control.

20. The system as claimed in any of claims 16–18 wherein the correction is accomplished by means of semiautomatic or automatic control.

21. The system as claimed in any of claims 13–20 wherein it comprises the device (18) of visualization for the user of information on location of the area of the aircraft forecasted positions and the vortex generator danger areas in the control plane.

22. The system as claimed in any of claims 13–20 wherein the indication unit (16) and emergency indication unit (17) are chosen from the group containing visual, audio and tactile units.

23. The system as claimed in any of claims 13–22 wherein the device (10) for determination of the vortex generator danger area parameters includes a device comprising:

the aircraft schematization unit (19) capable of calculating the set of geometrical data for the aircraft necessary for evaluation of the additional aerodynamic forces and moments affecting the aircraft, which are induced by the vortex generator wake vortices;

the unit (20) for evaluation of additional aerodynamic forces and moments affecting the aircraft at the given space point, which are induced by the vortex generator wake vortices, capable of calculating them on the basis of the saved information on the coordinates of the vorticity center path points in the form of the set of the vorticity region center paths in the inertial frame and the intensity of the vortex generator wake vortices; of information on the aircraft position, flight velocity, and angular rates in the inertial frame, as well as on the aircraft geometrical characteristics;

the unit (21) for evaluation of the hazard level of aerodynamic perturbations at the given space point capable of estimating the perturbation hazard level according to the hazard criterion chosen by the user;

the unit (22) for determination of a set of space points where the additional aerodynamic forces and moments induced by the vortex generator wake vortices are hazardous; capable of determining the coordinates of points belonging to the danger area on the basis of their selection under the hazard criterion chosen by the user;

the unit (23) for determination of the geometrical characteristics of the wake vortex danger area capable of calculating them on the basis of information on the coordinates of points belonging to the danger area.

24. The system as claimed in any of claims 13–23 wherein the admissible aircraft angle of roll is chosen as the hazard criterion.

25. The system as claimed in any of claims 13–23 wherein the admissible roll moment induced by the wake vortices is chosen as the hazard criterion.

26. The system as claimed in any of claims 23–25 wherein the unit (23) for determination of the geometrical characteristics of the wake vortex danger area is capable of approximating the danger area boundary.

27. The system as claimed in any of claims 13–26 wherein the wake vortex tracker (5) and forecasting device (9) comprise a programmable component and the device (10) for determination of danger area parameters is realized in the programmable component software.

28. The system as claimed in any of claims 13–27 wherein the device (10) for determination of danger area parameters comprises the database of characteristics of wake vortex danger areas for different types of vortex generators.

29. The system as claimed in any of claims 13–28 wherein it comprises the device for saving and/or transmitting information to the user on the delay time, coordinates of the control plane, the area of the aircraft forecasted positions and wake vortex danger areas of vortex generators located in the vicinity of the aircraft at least during the time of emergency indication of the nulling event for the distance from the area of the aircraft forecasted positions to the generator wake vortex danger area.